Claims

1. A method for segmentation of a digital image being represented by picture element data, the method comprising the steps of:

   - performing a watershed transformation of the digital image by applying a watershed transformation method on the picture element data to provide one ore more basins,

   - post-processing of at least one of the basins by processing the picture element data belonging to the at least one of the basins, where the post-processing is selected from the group of post-processing steps consisting of:
     i. gray-scale based segmentation,
     ii. visualization using a transfer function,
     iii. volumetry using histogram analysis.

2. The method of claim 1 further comprising:

   - determining a scalar value for each picture element by applying a transformation onto the corresponding picture element data,

   - applying the watershed transformation on the scalar values to provide the one or more basins.

3. The method of claim 1 whereby the digital image is a medical image, comprising one or more anatomical structures to be segmented.

4. The method of claim 1, the picture element data being three- or four-dimensional.

5. The method of claim 1 further comprising a step to prevent oversegmentation by means of applying one or more basin-basin merging rules during the watershed transformation.

6. The method of claim 5 wherein a preflooding rule is used as a basin-basin merging rule.

7. The method of claim 5 wherein a marker based rule is used as a basin-basin merging rule.

8. The method of claim 1 whereby the watershed transformation method is a hierarchical watershed transformation method.

9. The method of claim 1, the digital image comprising a first anatomical structure of a first tissue type having a first range of gray values and a second anatomical structure of a second tissue type having a second range of gray values, whereby the watershed transformation is performed to provide a basin comprising the first anatomical structure and a portion of the second anatomical structure, further comprising the steps of:

   - transforming the picture element data of the basin having gray values within the second range to make these picture elements transparent,

   - applying a transfer function to the picture element data having gray values between the first and the second ranges to gradually increase the transparency of the corresponding picture elements.

4. The method of claim 1, the picture element data being three- or four-dimensional.

5. The method of claim 1 further comprising a step to prevent oversegmentation by means of applying one or more basin-basin merging rules during the watershed transformation.

6. The method of claim 5 wherein a preflooding rule is used as a basin-basin merging rule.

7. The method of claim 5 wherein a marker based rule is used as a basin-basin merging rule.

8. The method of claim 1 whereby the watershed transformation method is a hierarchical watershed transformation method.

9. The method of claim 1, the digital image comprising a first anatomical structure of a first tissue type having a first range of gray values and a second anatomical structure of a second tissue type having a second range of gray values, whereby the watershed transformation is performed to provide a basin comprising the first anatomical structure and a portion of the second anatomical structure, further comprising the steps of:

   - transforming the picture element data of the basin having gray values within the second range to make these picture elements transparent,

   - applying a transfer function to the picture element data having gray values between the first and the second ranges to gradually increase the transparency of the corresponding picture elements.

10. The method of claim 1 further comprising analyzing a histogram of the picture element data of at least one of the segments for quantification purposes.

11. The method of claim 10 further comprising the steps of:

- providing a distribution function for each tissue type included within the segment,

- providing a partial volume function for each pair of tissue types,

- providing a total fit function based on the distribution functions and the partial volume functions,

- choosing parameters for the distribution functions and the partial volume functions to approximate the total fit function to the histogram,

- determining the volume of at least one of the tissue types within the segment by evaluating the parameters of the distribution function of that tissue type and of partial volume functions of pairs of tissue types which comprise that tissue type.

12. The method of claim 11 whereby the distribution functions are Gaussian functions and whereby the parameters of the partial volume functions are weighted by a factor of 0,5 for the evaluation.

13. A computer program product for performing a method in accordance with claim 1.

10. The method of claim 1 further comprising analyzing a histogram of the picture element data of at least one of the segments for quantification purposes.

11. The method of claim 10 further comprising the steps of:

- providing a distribution function for each tissue type included within the segment,

- providing a partial volume function for each pair of tissue types,

- providing a total fit function based on the distribution functions and the partial volume functions,

- choosing parameters for the distribution functions and the partial volume functions to approximate the total fit function to the histogram,

- determining the volume of at least one of the tissue types within the segment by evaluating the parameters of the distribution function of that tissue type and of partial volume functions of pairs of tissue types which comprise that tissue type.

12. The method of claim 11 whereby the distribution functions are Gaussian functions and whereby the parameters of the partial volume functions are weighted by a factor of 0,5 for the evaluation.

13. A computer program product for performing a method in accordance with claim 1.

14. A computer system comprising

- a memory component for storing picture element data of a digital image,

- a first program component for performing a watershed transformation of the digital image by applying a watershed transformation method on the picture element data to provide one or more basins,

- a second program component for post-processing of at least one of the basins by processing the picture element data belonging to the at least one of the basins to provide one or more segments.

15. The computer system of claim 14 further comprising a third program component for determining a scalar value for each picture element by applying a transformation only onto the corresponding picture element data and wherein the first program component is adapted to applying the watershed transformation onto the scalar values.

16. The computer system of claim 14 further comprising a fourth program component to apply at least one basin-basin merging rule to prevent oversegmentation during the watershed transformation.

17. The computer system of claim 14, the second program component being adapted to apply a transfer function to gradually increase the transparency of picture elements having gray values between a first range and a second range of gray values, the first and second ranges of gray values corresponding to first and second tissue types.

14. A computer system comprising

- a memory component for storing picture element data of a digital image,

- a first program component for performing a watershed transformation of the digital image by applying a watershed transformation method on the picture element data to provide one or more basins,

- a second program component for post-processing of at least one of the basins by processing the picture element data belonging to the at least one of the basins to provide one or more segments.

15. The computer system of claim 14 further comprising a third program component for determining a scalar value for each picture element by applying a transformation only onto the corresponding picture element data and wherein the first program component is adapted to applying the watershed transformation onto the scalar values.

16. The computer system of claim 14 further comprising a fourth program component to apply at least one basin-basin merging rule to prevent oversegmentation during the watershed transformation.

17. The computer system of claim 14, the second program component being adapted to apply a transfer function to gradually increase the transparency of picture elements having gray values between a first range and a second range of gray values, the first and second ranges of gray values corresponding to first and second tissue types.

18. The computer system of claim 14 further comprising a fifth program component for analyzing a histogram of the picture element data of one of the segments.

19. The computer system of claim 18, the fifth program component being adapted to determine a volume of a tissue type comprised within the segment by means of analyzing the histogram.

20. The computer system of claim 14, the first program component being adapted to perform the watershed transformation only once for a sequence of digital images and to maintain the segmentation result for consecutive digital images of the sequence, the second program component being adapted to perform the post-processing of the at least one of the basins by processing the picture element data of the actual digital image of the sequence belonging to the at least one of the basins to provide one or more segments.

18. The computer system of claim 14 further comprising a fifth program component for analyzing a histogram of the picture element data of one of the segments.

19. The computer system of claim 18, the fifth program component being adapted to determine a volume of a tissue type comprised within the segment by means of analyzing the histogram.

20. The computer system of claim 14, the first program component being adapted to perform the watershed transformation only once for a sequence of digital images and to maintain the segmentation result for consecutive digital images of the sequence, the second program component being adapted to perform the post-processing of the at least one of the basins by processing the picture element data of the actual digital image of the sequence belonging to the at least one of the basins to provide one or more segments.